Polychaete diversity and assemblage structure in the Oualidia Lagoon, Moroccan Atlantic coast

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ABSTRACT

Oualidia lagoon, a Ramsar Site on the Moroccan Atlantic coast, is heavily impacted mainly due to clam harvesting and fisheries. Understanding the functioning of the lagoon system appears as a fundamental knowledge for management and conservation. Having this in mind, 43 stations were sampled over the whole lagoon during winter 2013 and summer 2013 to analyse spatial and temporal distribution of the taxonomic composition, abundance and diversity of the polychaete assemblages. Among the thirteen species of polychaetes recorded, ten were newly reported for Oualidia lagoon. 1,051 individuals from 8 species occurred in winter and 2,784 from 13 species in summer. *Hediste diversicolor* and *Capitella* sp. were the most abundant taxa in both seasons, but only the former increased in density with the increasing distance form the lagoon opening. Temperature and salinity were higher, and Chl-a and OM were lower, in summer than in winter. Temperature and OM increased, and grain size decreased, together with an increasing distance from the lagoon opening, while salinity tended to decrease both in March and July and Chl-a tended to increase in March and to decrease in July. The structure of the polychaete assemblages was characterized by forming three main clusters, either based on sampling stations or on polychaete species. These clusters were organized according to a downstream gradient, with the stations having fine sediments and a *H. diversicolor* assemblage in the inner lagoon being replaced by stations with medium grain-sized sediment and a *Capitella* sp. assemblage in the mid-lagoon, which were in turn replaced by stations having sandy sediments and assemblages dominated by *Glycera alba* (winter) and *P. africana* (summer) in the areas closer to the lagoon inlets. The shift was, in fact, from a classical, brackish, lacunar assemblage to two different, temporal aspects of a marine assemblage (close to the inlets), with a transition assemblage in between. This corresponded with a typically paralic spatial structure whose main descriptors responded to a confinement gradient. Despite the absence of a river, the organization of the polychaete assemblages closely resembled that of an estuarine system, with the tidal regime playing a major driving role.

Keywords: Polychaete diversity, seasonal variability, assemblage structure, Oualidia lagoon, Morocco, Atlantic coast.

INTRODUCTION

Coastal lagoons are, in general, highly productive areas acting as transitional zones between land and sea. Nevertheless, anthropogenic pressure often tends to concentrate near coastal lagoons, thus becoming a major contributor to a decrease in water quality leading to habitat degradation (Newton *et al*., 2003).

This is certainly the case of Oualidia, a lagoon located in the Atlantic coast of Morocco. Oualidia lagoon is a Natural Park providing a valuable refuge to a rich variety of birds, fish, plants and other wildlife, being the most important wintering area for migratory birds in Morocco. Therefore, it is one of the twenty-four Moroccan sites considered by the RAMSAR Convention as wetlands of international interest. Through the practices of boating, bathing, camping, and traditional fisheries (including fish and molluscs), the lagoon and the surrounding area supports many aspects of the local economy, culture and community relationships and, consequently, a rapid urbanization has been generated during the recent years (Maanan *et al*., 2014). In turn, the different land uses around the lagoon (mainly agricultural, but also industrial) and its watershed produce various kinds of pollution, all of them affecting, to some extent, the lagoon environmental conditions. Among them, heavy metals (Zourarah *et al*., 2007; Idardare *et al*., 2008; Maanan *et al*., 2014) and fecal pollution (Hennani *et al*., 2012; Hassou *et al*., 2014).

The macrofauna is often used in coastal monitoring studies and, particularly in soft-bottoms, the polychaetes are a key group (Giangrande *et al*., 2005). The members of this group play an important role in the functioning of the benthic ecosystems, where they may represent up to 70% of the total abundance and biomass (Gray, 1974). The polychaetes are widely used as a key taxon in bioenvironmental studies to assess natural and human-induced disturbances, as they contain pollution sensitive and tolerant species that show differential distributions along pollution gradients (*e.g*. Pocklington & Wells, 1992; Gray *et al*., 2002; Venturini *et al*., 2004).

Previous studies on the lagoon functioning, including the macrofaunal component, were already carried out in some of the few Mediterranean Moroccan lagoons. Among them, the deep Nador lagoon, also known as Marchica (Guelorget *et al*., 1987; El Kamcha *et al*., 2015) or the shallower Smir lagoon (Chaouti & Bayed, 2008). In the Atlantic coast, the macrofauna has also been studied in a few lagoons, such as Merja Zerga (Bazaïri *et al*., 2003), Khnifiss (Bayed *et al.*, 1998; Dakki & Ligny, 1988; Lefrere et al. 2015) and Oualidia. In this lagoon, however, the studies mainly focused on macrobenthic taxa, such as molluscs, shellfish, or echinoderms (El Asri *et al*., 2015; Chbicheb, 1996), while the polychaete diversity was analyzed nearby, but in open coastal areas, Jerf Asfar and El Jadida, located at 55 and 70 km far from Oualidia (Sif *et al*., 2012).

Therefore, our study is the first one focusing specifically on the biodiversity and structure of the polychaete fauna in Oualidia lagoon, both under spatial and temporal approaches. Accordingly, we analyse the composition and structure of the assemblages, as well as their relationships with the main environmental variables explaining both their spatial distribution and their temporal variability in the enclosed ecosystem of the Oualidia coastal lagoon.

MATERIALS AND METHODS

Study area

Oualidia lagoon, 34°47'N-¬6°13'W and 34°52'N - 6°14'W, is located on the Atlantic coasts of Morocco (Fig. 1). The lagoon measures 7 km long and about 1 km wide. The basin occupies a north-south depression bordered by a continental cliff and a coastal consolidated dune ridge and water exchanges with the ocean occurs through a major inlet about 150 m wide. During spring tides there is also a secondary, shallower inlet about 50 m wide. The lagoon morphology is characterized by lateral channels, connected to a meandering main channel, with an average depth of 2 m and a maximum depth (during flood tides) that does not exceed 5 m (Carruesco, 1989). Flood tides cover more than 75% (2.25 km²) of the lagoon surface, bringing salt water up to the most confined, inner lagoon region, as well as into a saline marsh beyond the inner dam (Fig. 1).

Sampling and data analysis

Forty-three stations (Fig. 1) were sampled in winter (March 2013) and summer (July 2013). All samples (two replicates) were collected using a Van Veen grab (0.0625 m2 in surface area), except at station 43, which was located in rocky zone and was thus sampled by scraping sixteen 25×25 cm quadrats (until a total of 1 m² of surface area). The samples were sieved *in situ* through a 1 mm pore size mesh. The material retained on the mesh was transferred to containers and fixed in a fixed in a 10% formalin solution.

Each station was characterized by its distance from the lagoon opening (in Km), water salinity (‰) and water temperature (°C). An additional sediment sample was collected to analyse grain size, and organic matter and chlorophyll "a" contents. Grain size was measured with a laser granulometer (Malvern, Mastersizer) at the LETG (UMR 6554, University of Nantes) and expressed as mean grain size, in µm (to be used in the correlation analyses) and as relative proportions of sand, silt and clay, in % (to be used in the Canonical Correspondence Analysis, CCA). The percentage of organic matter (OM, %) was obtained as the weight losses of dried samples (24 h, 60°C) after ignition (4h, 450°C). The chlorophyll "a" content (chl-a, mg/m²) was determined according to the Lorenzen method (Holm-Hansen *et al*., 1965)

The macroinvertebrates were sorted under a binocular microscope, and the polychaetes were identified to species level, whenever possible, following Gil (2011). Currently accepted species names were checked at the World Polychaete Database (Read and Fauchald, 2017). Selected specimens of the most relevant species have been deposited in the CEAB collections (reference numbers CEAB.AP.856A and CEAB.AP.856B to CEAB.AP.868).

To analyse the structure of the assemblages, the following indices were calculated: (1) species richness (S: number of species per sample); (2) species abundance (N: individuals/m²); (3) diversity as indicated by the Shannon index (H', $\log_2$ basis) (Shannon, 1948); and the evenness index (J') (Pielou, 1966).

The relationships between environmental variables, species density and descriptors of the assemblage structure with the distance from the lagoon opening were analysed by Pearson correlations, which were performed with the XLSTAT software (2015.5.01.23039, copyright by Addinsoft 1995-2016).

Hierarchical Ascending Classification analyses (HAC) were done both on sampling stations and polychaete species, based on the Euclidean distance and the Wards method using log10(x + 1) to limit the influence of the most dominant taxa (Vakharia & Wemmerlöv 1995, Cao *et al*., 1997). Communities were identified by the IndVal index (Dufrêne & Legendre,

1997). Wilcoxon tests were used to determine the significance (P=0.05) of the difference between seasons. All these analyses were carried out using the STATISTICA version 8 for Windows software.

Canonical Correspondence Analyses (CCA) were performed, using the PAST 3.0 free software package, to analyse the relationships between environmental variables and polychaete assemblages. Environmental variables and polychaete densities were $\log_{10}(x+1)$ transformed prior to analysis. The significance of these relationships, as well as those of the assemblage descriptors with the environmental variables was assessed by Pearson correlation (performed with the XLSTAT software).

RESULTS

Environmental parameters

Temperature was significantly higher (r =0.000006; $p < 0.05$) in summer (16.1°C and 26.3°C) than in winter (16.9°C and 19.9°C) (Fig. 2). Salinity was also significantly higher (r=0.000215, $p < 0.05$) in summer (10.5 ‰ and 39.6 ‰) than in winter (10.1 ‰ and 39.5 ‰) (Fig. 2). Chl-a showed marked changes among the studied stations. Contrary to temperature and salinity, the Chl-a temporal pattern, as well as that of OM, showed significantly higher (r =0.000008, $p < 0.05$ and r=0.005282; $p < 0.05$) values in winter (1.19 and 23.41 mg/m² and 1.94 to 31.97%) than in summer (0.85 and 8.79 mg/m² and 1.73 to 15.1%) (Fig. 2).

All environmental parameters analysed except Salinity and Chl-a showed significant correlations with the distance from the lagoon opening both in March and July, positive for the temperature (Pearson coeff. = 0.758, $p < 0.001$ and Pearson coeff. = 0. 518, $p < 0.001$) and OM (Pearson coeff. = 0.440, $p = 0.003$ and Pearson coeff. = 0. 471, $p = 0.001$) and negative for the granulometry (Pearson coeff. = -0.338; $p = 0.027$ and Pearson coeff. = -0. 448, $p = 0.003$). Although non-significant, the salinity tended to decrease with the increasing distance from the opening both in March and July, while the Chl-a tended to increase in March and to decrease in July.

Polychaete abundance and structure

3,835 polychaete specimens belonging to 13 species were collected during this study (Table 1). Among them, 1,051 individuals from 8 species occurred in winter and 2,784 from 14 species in summer.

The three most abundant species in winter were *Hediste diversicolor* (72.4%), *Capitella* sp. (22.9%), and *Nepthys hombergii* (3.2%). The first two were also dominant in summer (64.7% and 17%, respectively), followed by *Panousea africana* (5.2%).

In winter, only *H. diversicolor* increased significantly its density together with the increasing distance from the lagoon opening (Pearson coeff. = 0. 337, $p = 0.027$. Conversely, in summer, there were no significant relationships with the distance from the lagoon opening, except for *P africana*, which showed a negative correlation (Pearson coeff. = -0. 340, $p < 0.026$).

Polychaete densities were significantly higher (r = 0.0007; $p < 0.05$) in summer (0 to 392 individuals/m²) than in winter (0 to 316 individuals/m²). The number of species ranged from 0 to 4 (winter) or 8 (summer). However, there were non-significant differences (r =0.190; $p > 0.05$) (Fig. 3).

The Shannon diversity was similar in winter (0-1.09 bits) than in summer (0-1.57 bits) (r = 0.091; $p > 0.05$) and, similarly, there were non-significant differences in evenness between both seasons (r = 0.241, $p > 0.05$) (Fig. 3).

The spatial distribution of the assemblage descriptors in winter revealed that only the polychaete densities were significantly, and positively, correlated with the distance for the lagoon opening (Pearson coeff. = 0. 381, $p = 0.012$). The remaining descriptors (S, J, H'), although non-significant, tended to increase with the increasing distance. Conversely, in summer, all descriptors tended to decrease with the distance from the lagoon opening. However, the relationships were non-significant for N and J., while they were significant in the cases of S and H' (Pearson coeff. = -0.397; $p = 0.008$ and Pearson coeff. = -0. 437, $p = 0.003$, respectively).

Three station clusters were obtained both during winter and summer in the HAC analyses, both for sampling stations and for polychaete species. Stations cluster 1 in winter (Fig. 4A) included 15 stations mainly from the inner region of the lagoon, characterized by having sediments mainly composed by silt and clay in different proportions, high temperatures and OM and a low average polychaete density (43.4 individuals/m²). The dominant species was *H. diversicolor*, followed by *Capitella* sp. (Table 2). Stations cluster 2 consisted of six stations occupying mostly the inner-central region of the lagoon, having silty sandy and clayey sandy sediments, a moderately high OM, temperature and salinity, and a high average density (56.8 individuals/m²). The dominant species was *Capitella* sp., followed by *H. diversicolor* (Table 2). Stations cluster 3 consisted of 13 stations mainly close to the lagoon opening, with predominantly sandy sediments, low temperatures and OM, and a relatively low average density (4.5 individuals/$m^{2)}$. The dominant species were *N. hombergii* and *Phyllodoce* sp. (Table 2).

During summer (Fig. 4B), stations cluster 1 was the largest one. It included 17 stations, mainly located in the inner central region of the lagoon, characterized by having relatively high temperatures, high OM, clay and silty clay sediments and a high average density (91.8 individuals/m^2). The dominant species was *H. diversicolor* (Table 2). Stations cluster 2 included 10 stations, located all along the lagoon, but mostly in the central part, with moderately high % OM and temperature, silty sand and clayey sand sediments a high average density (102.4 individuals//m²). As it occurred during winter, the dominant polychaetes were *Capitella* sp., followed by *H. diversicolor*. Stations cluster 3 included seven stations located mostly near the lagoon opening, characterized by having low temperatures and OM, very low Chl "a", a high percentage of sand, and the lowest recorded average density (28.6 individuals//m²). The dominant species were *P. africana*, *Diopatra* cf. *morocensis* and *Nephtys kersivalensis*.

The HAC analyses based on species also revealed the presence of three clusters in winter as well as in summer (Figs. 5A, 5B). Both seasons coincided in showing a species cluster 1 including *H. diversicolor* only, and a species cluster 2 including *Capitella* sp. only. Conversely, scpecies cluster 3 inlcuded five species in winter and eleven in summer.

Relationships between the descriptors of the polychaetes assemblages and the environmental variables

In winter, *Capitella* sp. and *N. hombergii* were positively correlated with OM (Pearson coeff. = 0. 367, $p = 0.015$) and Chl-a (Pearson coeff. = 0. 385, $p = 0.011$), respectively. In summer, *P. africana* showed a negative correlation with OM (Pearson coeff. = -0. 313, $p < 0.041$), while *H. diversicolor* and *N. kersivalensis* were positively correlated with OM

(Pearson coeff. = 0. 341, $p < 0.025$) and the granulometry (Pearson coeff. = 0. 480, $p = 0.001$).

In winter the first two CCA axes accounted for 85.93% of the observed variance. The species composition was mainly related to silt, OM and chl-a contents (Fig. 6A). In summer, the first two CCA axes accounted for 87.91% of the relationships, with the most influencing environmental variables being OM, clay and sand (Fig. 6B).

DISCUSSION

The structure of the assemblages inhabiting Oualidia largely responds to the estuarine processes and habitat mixing determined, at any given time, by the physical morphology relative to the tidal elevation inside the lagoon (El Asri *et al*., 2015). As it occurs all along the Moroccan Atlantic coast, tides and wind-generated waves are dominant (natural) processes governing the morphological developments (Kalloul *et al*., 2012). In Oualidia, however, the combined meteorological and riverine inputs are also shaping the environmental features. The salinity tended to be lower during winter as a response to the increasing precipitation, and rises in summer due to a higher evaporation rates, as well as to the lowering of the inland fresh water inputs. In addition, there was a marked upstream-downstream gradient, which the salinities being much lower upstream due to the arrival of inland freshwater (Fig. 2), as previously reported (Hassou *et al*., 2014; Hennani *et al*., 2012).

The winter increases in organic matter are linked to the arrival of a thick layer of mud following the rainwater runoff. In fact, the organic matter contents in Oualidia Lagoon were higher matter than those recorded at Moroccan lagoons, either Atlantic Sidi Moussa (3.6 and 12.3%) (Maanan *et al*., 2004) or Mediterranean Nador (0, 1 and 6.3%) (El Alami *et al*., 1998), but also of those in well studied European lagoons, such as the Venice lagoon (0.43 and 1.09%) (Bellucci *et al*., 2002). In turn, the high concentrations of chlorophyll "a", originated from the leaching of agricultural lands in the watershed, are so rich in nutrients that its arrival to the lagoon results in a significant increase in chlorophyll 'a'.

Our study represents a significant contribution to the knowledge on the polychaete macrofauna living the Oualidia lagoon, as the number of species reported is almost three times than those reported by Chbicheb (1996) during four seasons from December 1992 to November 1993 (Table 1). On the other hand, 12 out of the 14 species recorded in 2013 were not listed in previous survey, while two found in 1996 appear not to be currently present (*Nephtys caeca* and *Owenia fusiformis)*. These differences in the structure and diversity of the polychaete assemblages may likely be explained by the increasing levels of organic matter in the sediment, which may also be related with the changes in the hydrodynamics of the lagoon due to the construction of a pit upstream. On the other hand, despite its relatively small size, Oualidia lagoon supports rather diverse polychaete assemblages, but also of molluscs (El Asri *et al*., 2015), when compared with other African lagoons: Aby lagoon (9 species) (Koaudio *et al*., 2008); Smir lagoon (12 species) (Chaouti & Bayed, 2005); Epe lagoon (10 species) (Uwadiae, 2009), Khnifiss lagoon (17 species) (Lefrere *et al*., 2015). The fact that some species could not be fully identified obey mainly to the bad preservation status of the collected materials (e.g. in the case of *L.*cf. *koreni* or *G.* cf. *tridactila*). On the other hand, there were only anterior fragments of *D.* cf. *morocensis*, the specimens of *Phyllodoce* were likely juveniles to small to distinguish the key taxonomic characters or the specimens of *Harmothoe* completely lack the elytra. Despite we were certain of the specimens' assignation to individual species, a requisite for biodiversity analyses, further efforts would be addressed to allow more detailed taxonomic studies that would help in confirming the identity of the doubtful species. If possible these studies would have to include samples for molecular

studies, which would be particularly helpful in identifying species such as those belonging to the *Capitella* sibling species complex (Tomioka *et al.*, 2016). Despite it intrinsic interest, these studies are far beyond the scope of the present paper.

In the Oualidia lagoon, the three most abundant species were *H. diversicolor*, *Capitella* sp. and *N. hombergii*. The first two were also the most dominant in summer (64.7% and 17%, respectively), followed by *P. africana* (5.2%). This pattern of dominance differs completely with that reported in the Khnifess lagoon, where the most representative species were *D. marocensis*, *Terebella lapidaria* and *Nicomache lumbricalis* (Artemis *et al*., 2006). The first one was also present in Oualidia, but its abundance was very low. In the Smir lagoon, the three most dominant species were *Streblospio shrubsolii* (reported as *S. dekhuyzeni*)*, H. diversicolor* and *Alkmaria romijni* (Chaouti & Bayed, 2008). Coastal lagoons are highly variable in terms of environmental conditions, not only between their different areas, but also seasonally. This may certainly contribute to explain the reported changes in composition and dominance of the assemblages inhabiting different lagoons, but also to drastic changes in the species composition through time, particularly if there are associated changes in anthropogenic pressures (Hernandez-Guevara *et al.*, 2008). These changes, however, are not only related to the ability of the species to respond to the environmental changes, but may also result from the existing biological interactions such as competition or predation, or may depend on intrinsic characteristics of the species, as previously discussed for similar environments (Artemis *et al*., 2006).

Despite the temporal environmental differences found in the lagoon, and, to some extent, the differences in composition, the structure of the assemblages was the same during the two study periods. Environmental descriptors, and particularly those related to the sediment granulometry showed a regular gradient, which was mirrored by the polychaete assemblages. In fact, the *H. diversicolor* assemblage found in the fine sediments of the inner lagoon were replaced by the *Capitella* sp. one in the medium grain-sized sediment of the mid. lagoon, and by the *Glycera alba* (winter) and *P. africana* (summer) ones in the sandy sediments closer to the inlets. The shift was, in fact, from a classical, brackish, lacunar assemblage to two different, temporal aspects of a marine assemblage (close to the inlets), with a transition assemblage in between.

In Oualidia, continental and marine environments are characteristically interfingered, as typically occurs in littoral lagoons (Amanieu *et al*., 1980), the so-called paralic environments sensu Guelorget & Perthussot (1992). Moreover, the structure of the lagoon and the associated benthic communities defined on the basis of our data agrees with the previous findings based on a physical oceanography approach that defined the lagoon as "an estuary without a river" (Hilmi *et al*., 2005). This structure, as well as the functioning and the influence of the nearby agricultural fields reaching the lagoon through fresh groundwater inflows, closely resembles that described for Alfacs Bay in the Ebre's Delta (Iberian Peninsula). In this lagoon, both meio-and macrofaunal organisms are overall arranged in three main assemblages (marine, transition and brackish) from the opening to the see to the most confined part (Palacín *et al*., 1991, 1992). In this bay, these authors also suggested an estuarine regime in absence of a river. The main difference, from an oceanographic point of view, is that the leading force in Oualidia are tides, while in Alfacs, the main currents are mainly wind and density generated, as Mediterranean tides are virtually negligible (Camp & Delgado, 1987). On the other hand, the highest surface and water volume, together with the largest area not submitted to confined conditions, lead to maintain much diverse assemblages in Alfacs Bay. This is particularly evident when specifically analysing the polychaetes: three assemblages in Oualidia vs. six in Alfacs, 14 species and maximal densities of less than 200 individuals/m^2 in Oualidia vs. one hundred species and up to 23,000 individuals/m^2 in Alfacs (Martin *et al*., 2000).

Despite its relatively small size, Oualidia lagoon revealed to be, in many different senses (from oceanography to benthic ecology), an interesting environment. This, combined with the numerous human activities developed in the surroundings, as well as in the lagoon itself, and the declaration as a Natural Park, clearly target this lagoon as an interesting monitoring objective. Future surveys will not only show the expected changes triggered by the increasing anthropogenic influence, but may also be important in assessing the health of the lagoon ecosystem, a key issue to promote initiatives allowing to maintain or even improve the added values of the lagoon both from a naturalistic point of view (e.g. as a wintering area for migratory birds) and as a service provider (e.g. sailing, bathing, bird watching, another touristic activities).

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Table 1: Comparative analysis of the polychaetes identified in our study with those identified by Chbicheb (1996) in Oualidia lagoon

Family	Species	This study		1996
		Winter	Summer	
Nereididae	*Hediste diversicolor* (O.F. Müller, 1776)	*	*	*
Capitellidae	*Capitella* sp.	*	*	*
Ampharetidae	*Alkmaria romijni* Horst, 1919	*	*	
Sabellidae	*Panousea africana* Rullier & Amoureux, 1970	*	*	
Nepthyidae	*Nephtys hombergii* Savigny in Lamarck, 1818	*	*	*
	Nephtys kersivalensis McIntosh, 1908		*	
	Nephtys caeca (Fabricius, 1780)			*
Phyllodocidae	*Phyllodoce* sp.	*	*	
Onuphidae	*Diopatra* cf. *marocensis* Paxton, Fadlaoui & Lechapt, 1995	*	*	
Glyceridae	*Glycera alba* (O.F. Müller, 1776)	*	*	
	Glycera cf. *tridactyla* Schmarda, 1861		*	
Lumbrineridae	*Lumbrineris coccinea* (Renier, 1804)		*	
Polynoidae	*Harmothoe* sp.		*	
Pectinariidae	*Lagis* cf. *koreni* Malmgren, 1866		*	
	Owenia fusiformis Delle Chiaje, 1844			*

Table 2 List of the main species of each polychaete assemblages according to the IndVal index. Assemblages are named according to the species showing the highest IndVal (in bold).

Season	Cluster	Species	IndVal
Winter	1	***Hediste diversicolor***	238.4
		Panousea africana	19.1
		Diopatra cf. marocensis	19.1
	2	***Capitella* sp.**	651.2
		Hediste diversicolor	114.0
		Alkmaria romijni	29.9
	3	***Glycera alba***	94.5
		Phyllodoce sp.	63.0
		Nephtys hombergii	50.0
Summer	1	***Hediste diversicolor***	169.8
		Alkmaria romijni	5.9
		Harmothoe sp.	3.9
	2	***Capitella sp***.	340,0
		Glycera alba	120.9
		Lumbrineris coccinea	87.4
	3	***Panousea africana***	179.6
		Diopatra cf. *marocensis*	138.8
		Nephtys kersivalensis	55.5

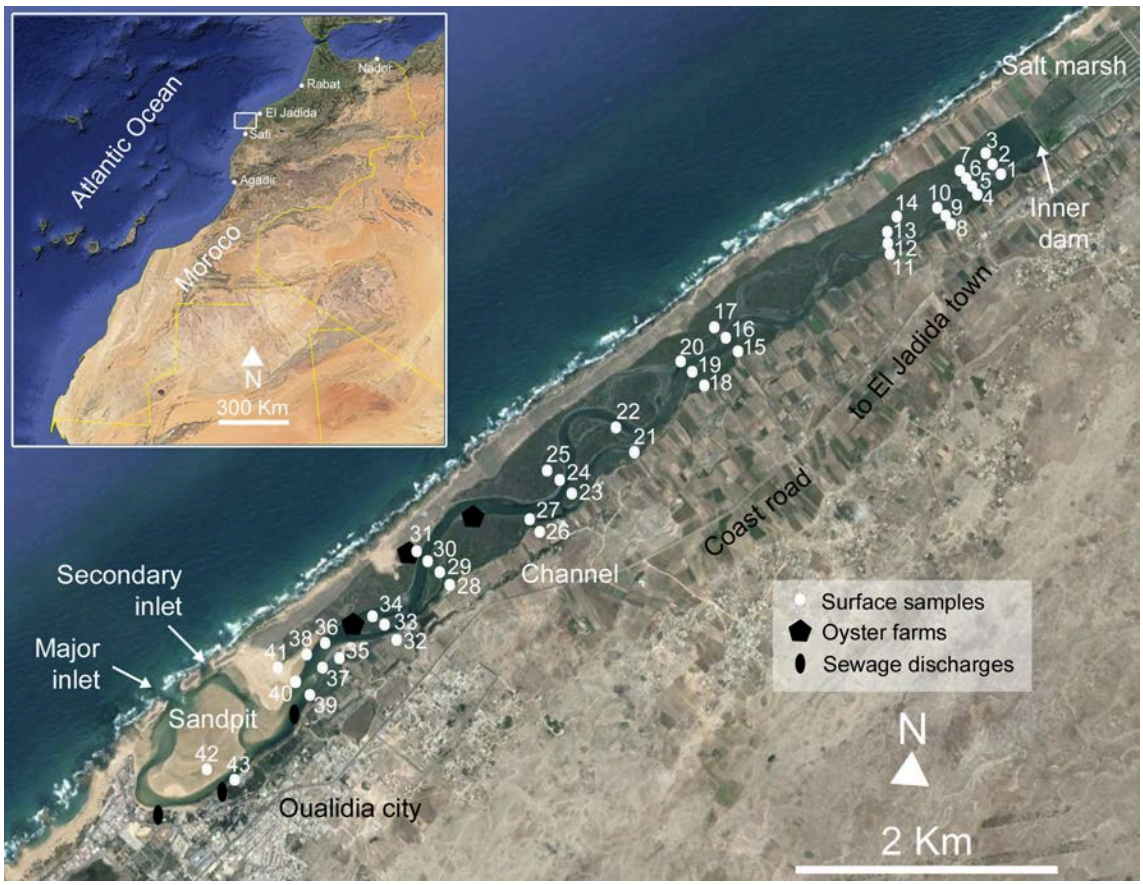

Fig.1. Map of the study area, showing the location of sampling sites in Oualidia lagoon.

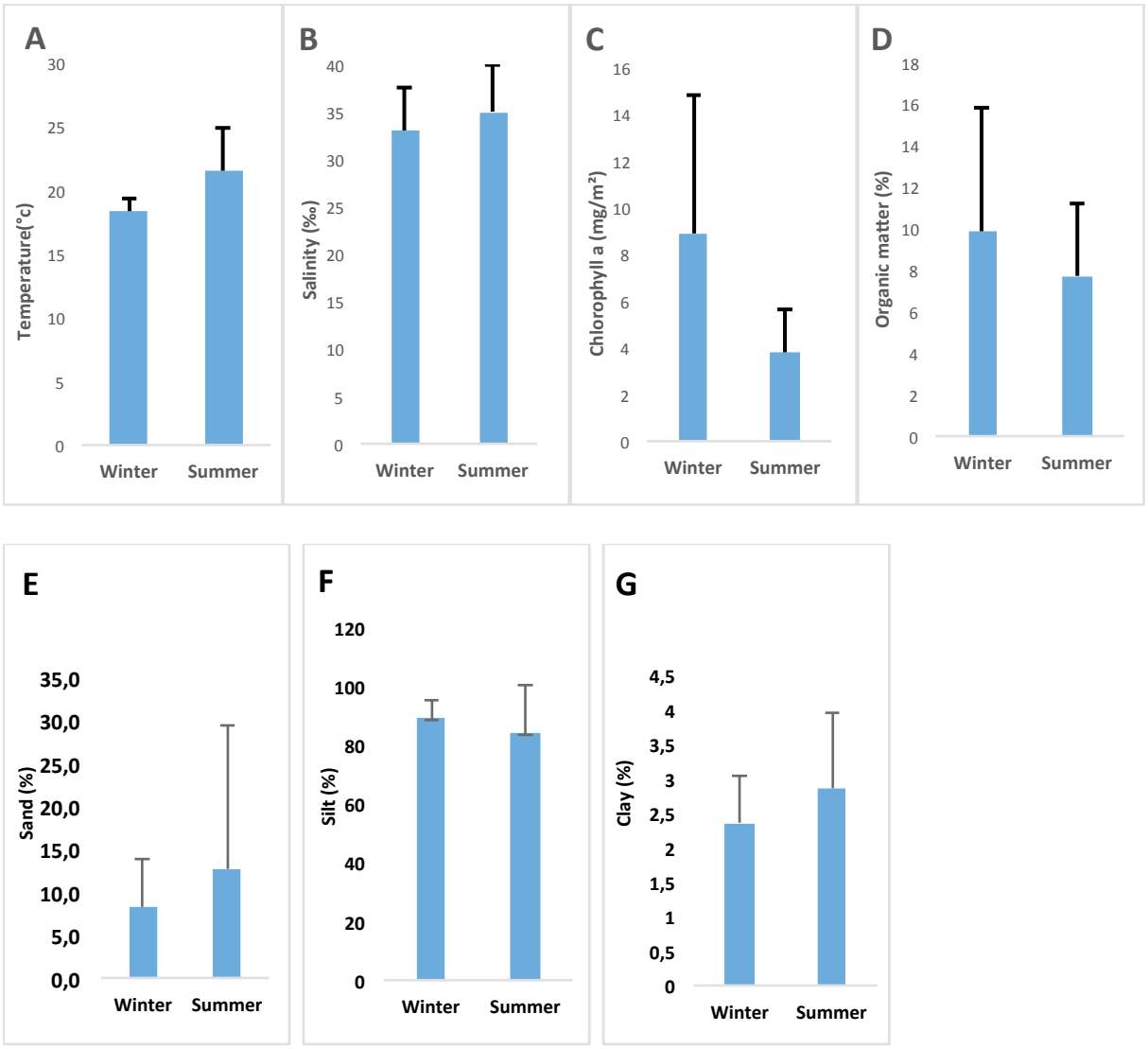

Fig. 2. Winter and summer differences in water temperature, water salinity, organic matter, chlorophyll "a" content and granulometry (Silt, Clay and Sand contents) in the sediment of Oualidia lagoon. Mean ± sd.

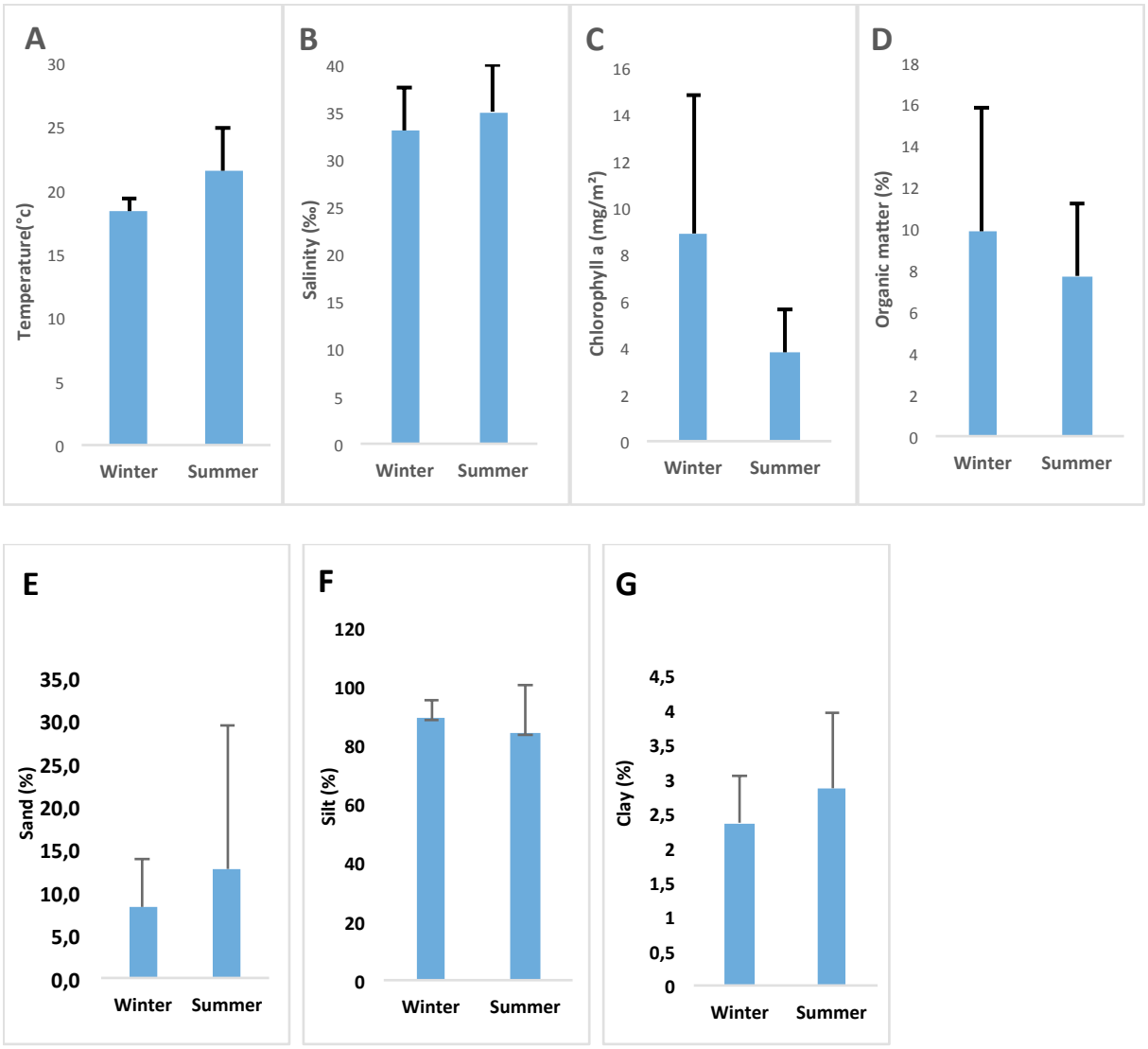

Fig. 3. Winter and summer differences in the main descriptors of the structure of the polychaete assemblages. A. Density (ind. m-²). B. Species richness. C. Shannon diversity. D. Evenness.

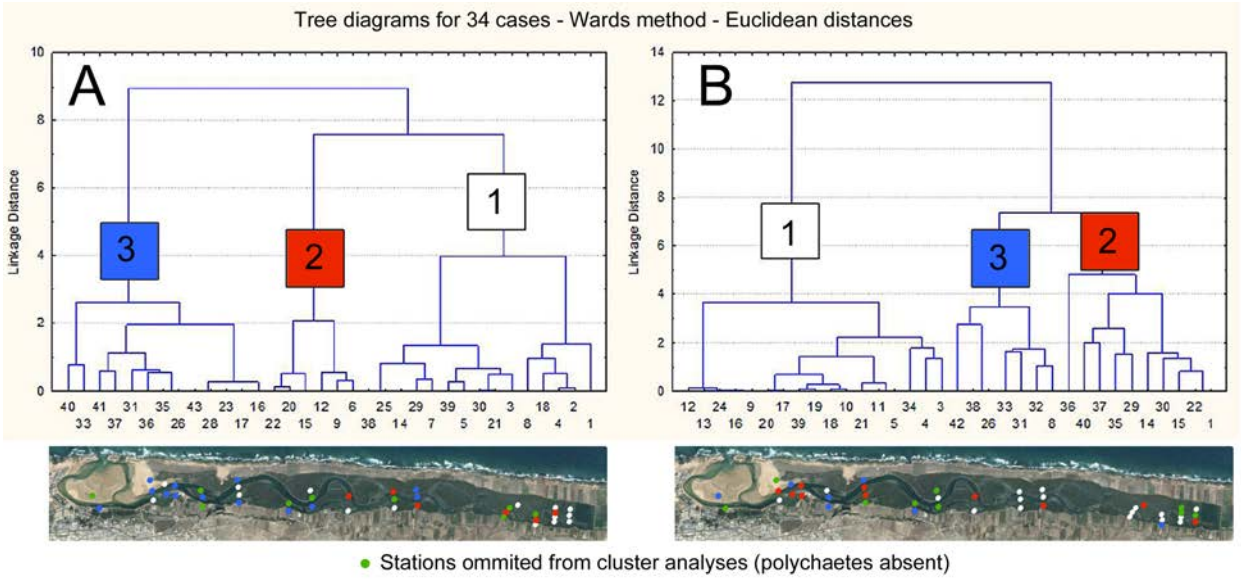

Fig. 4. Winter (A) and summer (B) dendrograms showing the three station clusters obtained in the Hierarchical Ascending Classification analysis, and the location of the respective stations in the lagoon.

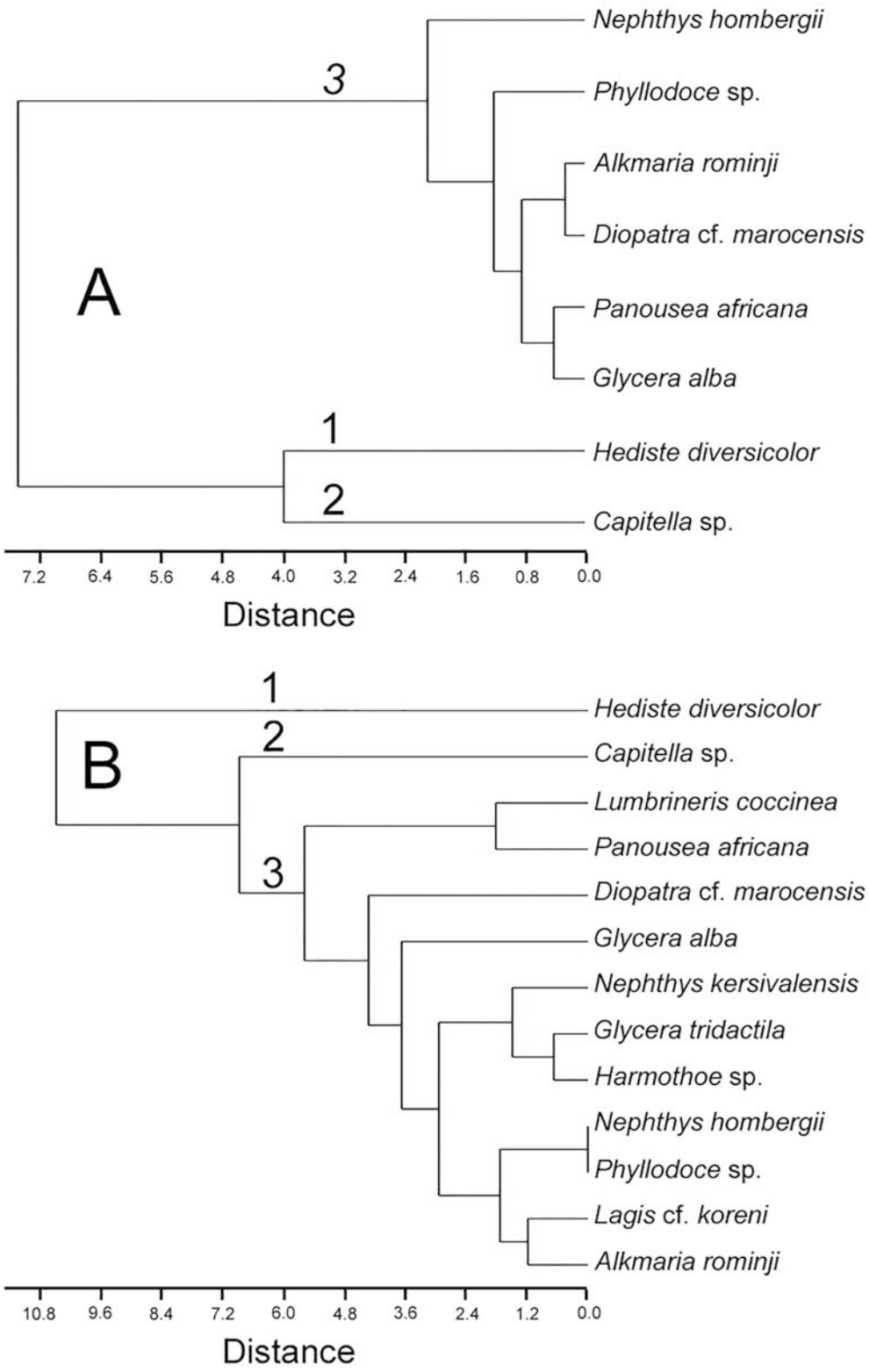

Fig. 5. Winter (A) and summer (B) dendrograms showing the three species clusters obtained in the Hierarchical Ascending Classification analysis.

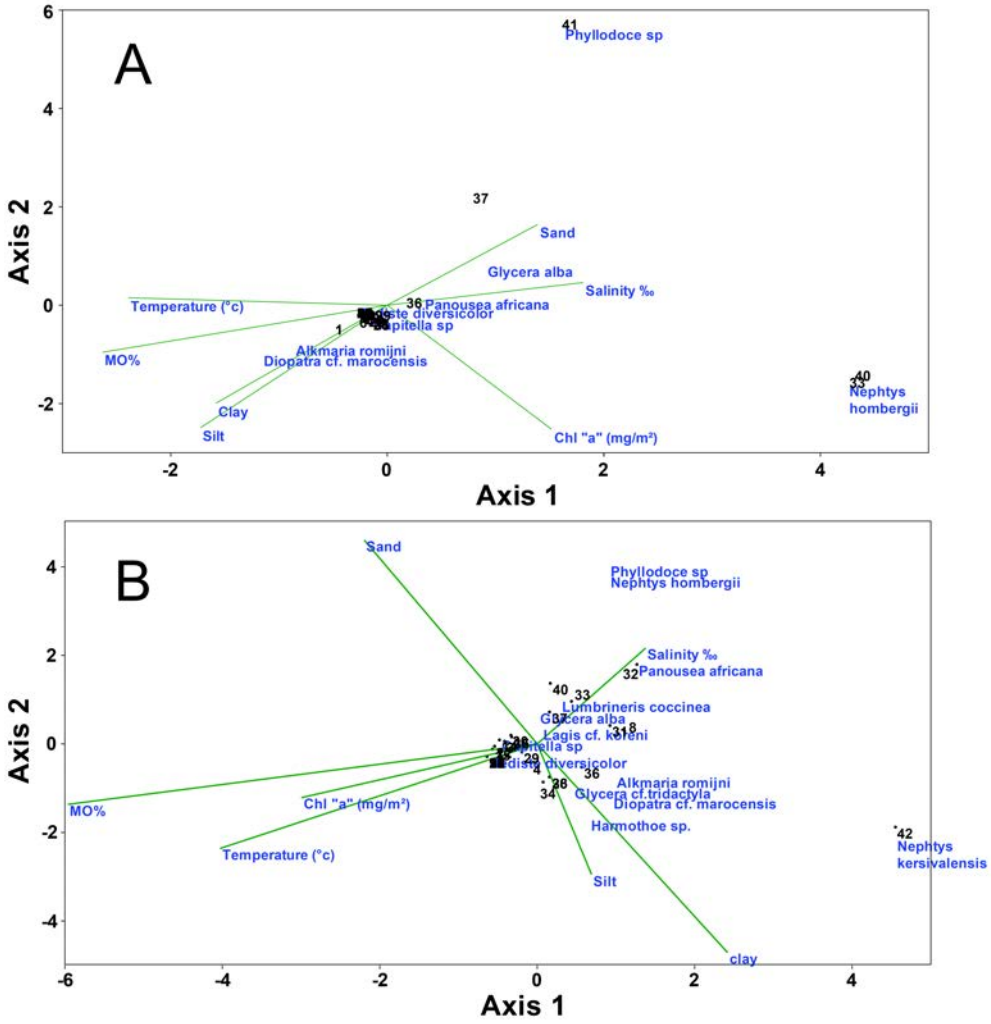

Fig. 6. Canonical Correspondence Analysis plots. A. Winter. B. Summer.